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Extended Abstract

Wireless Sensor Network for Sustainable Agriculture †

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Abstract: Precision agriculture can be defined as the science of using technology to improve the agricultural production. It is advisable for farmers to use a decision support system; in fact, real–time monitoring of climatic conditions is the only way to know the water needed by a cultivation. On the other hand, since the 1990s, a strong decrease of the *Mediterranean Quercus* has been observed in the pastures of southwestern Spain and Portugal, causing a high mortality of holm and cork oak trees. Among the factors associated with this decrease, the radical decomposition caused by *Phytophthora Cinnamomi* is remarkable for its gravity, which makes it necessary to reforest the trees and to monitor the microclimatic factors that have an influence on this regeneration. Wireless Sensor Networks (WSN) are a technology in full evolution and development, as well as their appropriate use in cultivations that help to implement ecological techniques. With these considerations in this work five units/nodes with one or more sensors that allow different environmental readings have been developed. In this work, the acquisition of data obtained from different sensors has been achieved, allowing the monitoring of climatic elements such as soil moisture, air quality, temperature and humidity, rainfall intensity, precipitation level, wind speed and direction, luminous flux and atmospheric pressure. A web page has been designed where the user can consult the climatic conditions of the cultivation or reforestation. Different devices interconnected with a central unit have been developed where measurements of the cultivation are sent for its later analysis by the farmer. The microclimatic data acquisition developed in the WSN proposed in this paper allows a farmer to make decisions about the irrigation of the cultivation, use of fertilizers, the development and maturation phases of the cultivated products, obtaining the optimum stages of cultivation and harvesting.

Keywords: sustainable agriculture; Farm Management Information Systems (FMIS), wireless sensor network (WSN), precision agriculture (PA); environmental monitoring; Internet of Things

1. Introduction

Agriculture has played an important role in the development of human civilization. Due to the increased demand of food, additional efforts and special techniques are being developed to multiply food production. Modern agriculture requires a larger production of food to meet the needs of the great global population. To achieve this goal, new technologies and solutions are being applied in agriculture to provide an optimal alternative for collecting and processing information to improve productivity. In addition, the alarming climate change and water scarcity demand new and improved methods for modern agricultural exploitations. The need for automation then appears, and intelligent decision making is becoming more important to achieve this goal. In this sense, technologies such as ubiquitous computing, wireless sensor networks (WSN), radio frequency modules (RFID), cloud computing, Internet of Things (IoT), satellite monitoring, remote sensing, etc. are becoming increasingly popular. The rise of wireless sensor networks has stimulated a new direction in agriculture. Recently, WSNs have been widely applied in various agricultural applications. Several articles that perform a state of the art review on the field of WSNs in agriculture have been selected [1–8].

2. System Architecture

With these considerations, in this work, it has been achieved, through a series of electronic devices, the acquisition of data obtained using different sensors allowing us to study the evolution of different physical elements such as soil moisture, air quality, ambient temperature and humidity, rainfall intensity, precipitation level, wind speed and direction and atmospheric pressure. One of the restrictions that characterizes this type of technology is the power supply of the devices, since in areas without commercial power lines, such as the pasture, another way of supply must be looked for. This type of restriction has been taken into account in this work and different ways of powering these devices have been used, including batteries and solar panels.

For this purpose, different sensors connected to a microcontroller have been used to be able to control, evaluate and understand the development of the implanted cultivation and to be able to anticipate the changes it may need by performing different actions depending on the type of event. For the design of a precision agriculture, a complete knowledge of the application environment is required. In order to obtain this knowledge, it is necessary to use some tool that facilitates it. The tool used is WSN (Wireless Sensor Network) technology which, together with the use of precision sensors, provides the development a more efficient resolution. Different units/nodes (arduino nano) with one or a series of sensors have been designed which will produce the different environmental readings. There will also be an RFID communication module, NRF24L01, which will allow the data to be sent to a central node (Raspberry PI) in charge of processing and storing them in a web server so that it can be easily accessed, managed and used by a user. The units designed are shown in Figure 1.

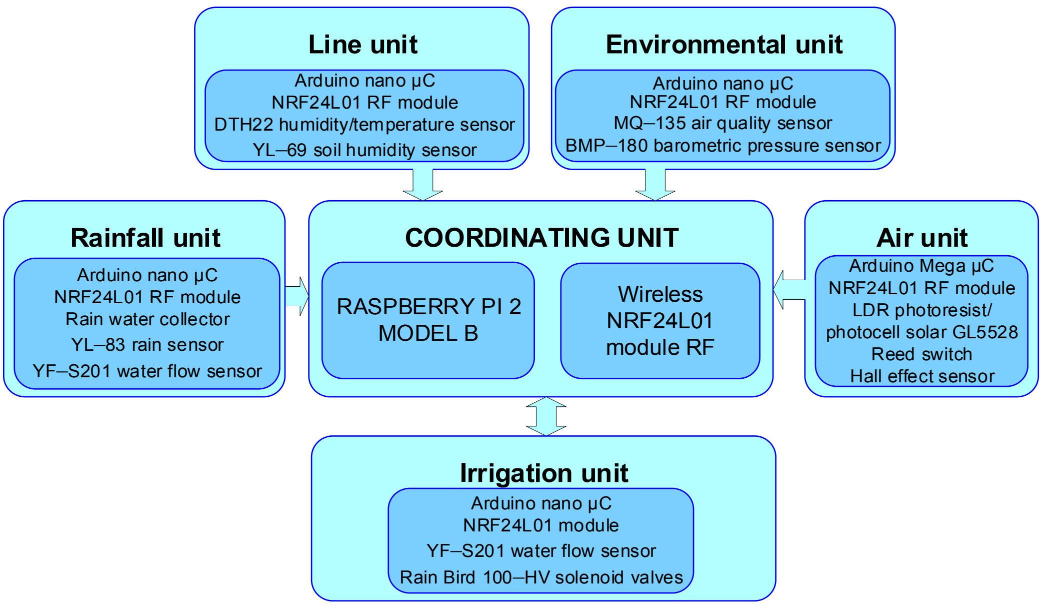


Figure 1. Hardware units of the system architecture and its components.

A Web platform has been developed, named Snail–Web, under the Phalcon PHP framework. With this web the user, besides receiving structured information about the readings of the different nodes implanted in the area where the trees have been planted, will have the opportunity to determine exactly the irrigation requirements and the use of fertilizers, the development and maturation phases of the trees, and to achieve the optimum plantation points, etc. An example of the web developed is shown in Figure 2.

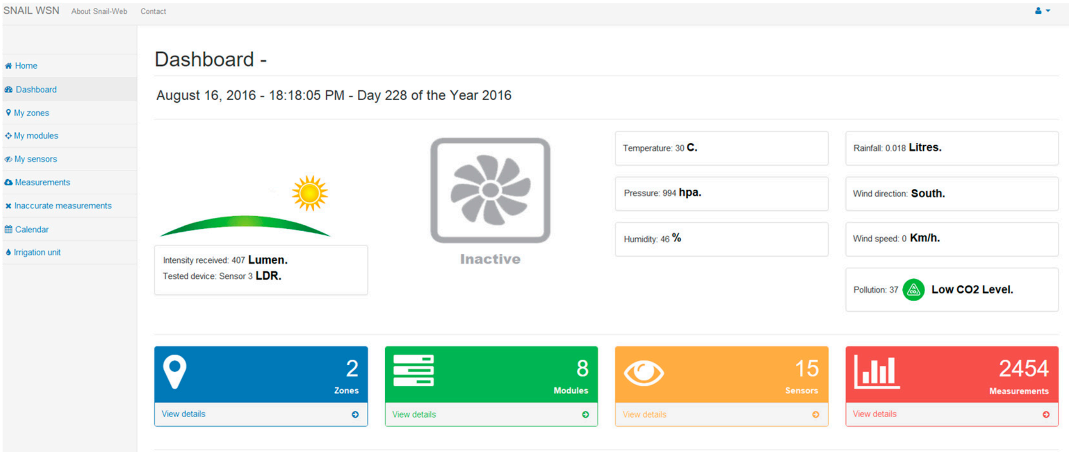
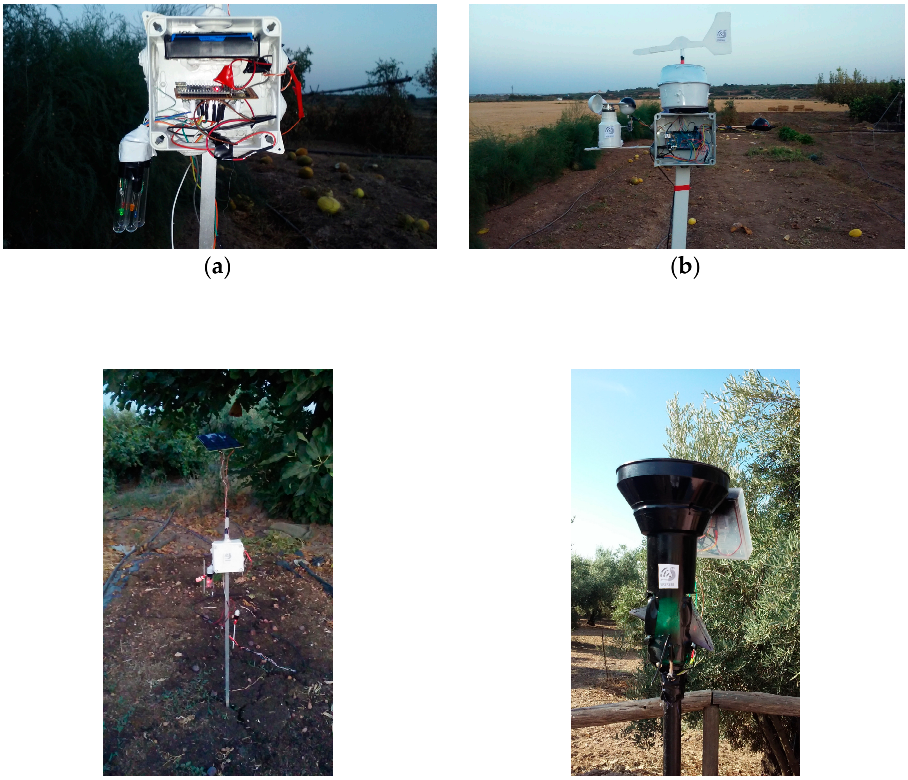


Figure 2. Dashboard of the owner user.

The prototype developed has actually been tested in a vegetable garden with satisfactory results, with a laptop computer and its submission to the website. In Figure 3 several images of different units implemented in a real situation are illustrated.



(**a**) (**b**)

(**c**) (**d**)

Figure 3. (**a**) Environmental unit, (**b**) Air unit (**c**) Line unit, (**d**) Irrigation unit.

3. Conclusions

A prototype system that can monitor different environmental characteristics required for any type of cultivation has been developed. The solution proposed in this work has been a WSN composed of several units with different sensors (line unit, environmental unit, air unit, rainfall unit and irrigation unit), allowing the monitoring of climatic element. These sensors send their information to a coordinating unit that processes them and sends them to a web portal so that any farmer can obtain information about the state of his agricultural exploitation and can act on it adequately. Efforts have been made to ensure that the construction of the system can be modularized so that it can be extended or modified in the future.

This system has been implemented with satisfactory results in a real vegetable garden. Once the positive results have been achieved, the system is ready to be used in the next phase of development, which is the real main motivation of this work: Apply this system to the monitoring of small holm oaks in the reforestation of the pastures of southern Spain, which is one of the reasons why there is some involvement from both the scientific community and the public administration. There are more current studies [9] that justify the use of technological applications for the control of climatic conditions and the control of available water, such as the one we have developed in this paper.

Author Contributions: C.D.M.-M. has been leading the software and application layer. M.B. has been leading the research project and leading the communication issues as well as electronics and interfacing. F.J.Q.-L. has been working in the HW design, firmware development and test. M.A.O. has been leading the tasks concerning WSN technologies. M.Á.M.-V. he has been in charge of the physical installation in the real test scenarios mounted. A.G. has been working in the HW design, development and test

Conflicts of Interest: The authors declare no conflict of interest.

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